Crash Helmets for Eggs

- Crash Helmets for Eggs is a design and build activity in which pupils investigate the materials used in the construction of crash helmets.
- It is a useful way of introducing some of the scientific thinking concepts pupils will have been learning, such as the idea of fair testing, forces and energy, structure of materials and how they link to properties, key stages in performing an experiment.
- The activity works equally well as part of a science or design & technology lesson and is in fact a really good way of linking the two subjects.
- Pupils work in teams to complete the task and the number of teams is only limited by the amount of space and time that you have to run the activity. Ideally no more than 20 teams should take part (40 pupils in pairs or 60 in groups of three) as with more than this the testing phase becomes very drawn out. With larger numbers you could introduce heats.
- This activity has been incorporated into the **Can you make it?** project where the initial introduction and research phases are done at the end of the first session, the design and build phases are done in science lessons between sessions and the test and evaluation phases are done during the second formal session.
- Crash Helmets for Eggs can also be run as a standalone activity in about an hour and approximate timings are given in brackets for this purpose.
- These notes are split into the following sections:
    - Preparation and materials
    - Introduction
    - Research phase
    - Design phase
    - Build phase
    - Test phase
    - Evaluation phase

Prepared by
Dr Diane Aston, IOM3

Preparation and materials

- If you are running this activity as part of the **Can you make it?** project all consumables except sticky tape and eggs will be provided.
- If you are running this activity yourself, you will need to start squirreling away packaging materials to use to build the designs. I usually provide **packaging chips** that come in all sorts of varieties (you can buy these cheaply from stationary shops or get people collecting them for you), **foam or sponge** (I usually buy cheap pan scourers and pull off the scouring bit!) and **bubble wrap** (again I get people collecting this for me but usually end up buying some from the stationers). I bag up the materials beforehand to make it easier on the day; each group gets about 15 packing chips, a roughly 15x15cm sheet of bubble wrap and a piece of foam approximately 8x8x2cm. During the activity, the groups each get a 50cm length of **parcel tape** to stick their designs together with and **scissors** to cut the stuff up with.
- You will need to buy enough **eggs** for one per team. I usually buy free range medium (free range have much tougher shells), varying in weight from about 55 to 70g. Just before the activity I number and pre-weigh the eggs to save time during the activity. You will need some **scales** during the activity so the groups can re-weigh their eggs wearing the crash suits. A pair of ordinary kitchen scales will do fine.
- A set of **stepladders** is useful to stand on to test the designs I would also recommend that you get some **plastic sheet** or a bin bag to put on the floor as a drop zone during testing as things can get messy!
- You will need to enough **worksheets** for one per team and you will need a **master sheet** so you can record the results. The worksheet has a summary of the introduction on the front and on the back has space for the pupils to write their team name, draw their design and record their results.
- I would recommend that you do this activity in a classroom or workshop without a carpet as dropping the eggs can be messy and it is difficult to get bits of expanded polystyrene out of carpet (speaking from the experience of picking it out by hand!).
- If appropriate you can layout and number each workstation with a worksheet, pencil(s), bag of materials, sticky tape and scissors prior to the group coming in and ask the pupils to go their numbered station as they enter the room. Always hand the eggs out later!

Prepared by
Dr Diane Aston, IOM3

Introduction (5 minutes)

- Explain to the pupils that they will be working on their challenge in teams just as real scientists or engineers would do if they were working on a multi-million-pound project in industry.
- Explain that it is important to be able to put aside personal differences to work together to come up with the most effective solution; this is how the real-world works! Sometimes when you get a job you start out working with people you do not know and after a while you may find that you don't get on, but you have to make the best of the situation.
- Explain to the group that they will be working with limited resources and will have to work to tight time deadlines.
- Explain the importance of good record keeping throughout the project just as real scientists and engineers do. Sometimes university or industry projects go on for years and it is important to be able to refer back to earlier work.
- Explain that their project will be split into four sections:
  - Research the problem
  - Come up with a design to solve the problem
  - Build the design
  - Test and evaluate the design
- Introduce the challenge:

  To design and build the lightest possible crash protection suit to prevent an ordinary (not hard boiled) hen's egg from breaking when dropped on to the ground from a height of about two metres.
- Explain that certificates and prizes will be given for the lightest design that protects the egg and the best team name.

Prepared by
Dr Diane Aston, IOM3

Research phase (10 minutes)

- Rather than getting the pupils to go and do their own research in the library or on the internet we look at cycle helmets and why it is important that you wear one.
- Encourage the pupils to think about all the things a cycle helmet needs to do or be when you are wearing it, such as it has to:
  be streamlined · be cheap · be easy to mass produce · be comfortable · be durable · look nice / be different colours · fit your head and lots of other sizes and shapes of peoples' heads · fasten on to your head so it can't fall off · have holes in to keep your head cool
- But the most important things are that it is **lightweight** and **compact**, that it is a **close fit** (if you wear a helmet that is too big, when you fall off your helmet hits the floor and then your head hits the inside of the helmet and it can still do serious damage) and crucially it is a **good shock absorber**, i.e. it will absorb the energy of an impact.
- I usually have a real helmet on hand to demonstrate and explain that cycle helmets are generally made from three layers of material (see next page).
- The idea is for the teams to use cycle helmets as the basis for their design, i.e. to design something which will absorb energy on impact rather than slow the fall of the egg; **parachutes and wings are banned!**
- It is worth re-iterating to the pupils that their design needs to go all the way round the egg to make a suit rather than on just one end like a helmet, as you can't easily control the way it will fall when dropped.
- Introduce each of the different materials that they can use to build their designs and explain that these materials all contain air bubbles. In some cases, these are big enough to see, such as in bubble wrap but in other cases they are too small to see. I encourage the pupils to look after the air bubbles as these will protect the egg. If they pop the bubbles in the bubble wrap (tempting as it is) they will ruin its energy absorbing properties!
- Introduce the concept of fair testing and get the pupils to identify all the variables and decide whether they are constant (e.g. egg size, amount of material, height of drop etc.)
- Encourage the teams to come up with a name – the eggier the better! Past contenders include Eggheads, Eggineers, Eggsperimentalists, Eggsterminaters, Eggsperts, Eggstremists, all things scrambled and cracking, I've had an Egghog that looked like a hedgehog and an Eggloo that looked like an igloo and my favourite from a year 11 team, an oeuf is an oeuf! One of the best was SupaAntiCrackaNotACHanceAShockAbsorba!

Prepared by
Dr Diane Aston, IOM3

Cycle helmets explained...

- Cycle helmets are generally made from three layers of material:
  - An outer layer of hard plastic is designed to make the helmet durable and wearable in lots of different kinds of weather. It can be coloured to make the helmet look nice, but its main function is to protect the middle layer from minor damage such as denting and scratching.
  - The innermost layer is usually made of sponge and its function is to make the helmet fit closely and be comfortable. In many helmets you get several bits of this foam in different thicknesses so you can fine tune the fit
  - The middle layer is the most important as this absorbs the energy of the impact. It is usually made from a polymer foam such as expanded polystyrene.
- Foams are types of plastics that are full of air bubbles. They are made by puffing up beads of plastic when it is soft and if you look at foam under a microscope it will look a bit like Aero chocolate - it is full of bubbles.
- When you fall off all the little bubbles in the area of the helmet that you have landed on squash and as they do this they absorb the shock and stop it going through to damage your skull.
- The reason that you have to buy another helmet if you have fallen on yours once is that these little air bubbles or cells don't spring back to shape when the squashing force is removed. This is different to the foam in the soles of your training shoes which is designed to squash and unsquash repeatedly.

Prepared by
Dr Diane Aston, IOM3

Design phase (10 minutes)

- It is useful to put the materials packs on the tables so the students can look at and explore them during the design stage.
- Encourage the teams to assign a scribe to document the ideas. Perhaps ask them to draw a neat labelled diagram of their idea or create a flow chart of how they are going to build their design.
- Write the names of the materials on the board so that they know what they have to choose from and how to spell them correctly.
- Explain that they can choose to make their crash suit from one type of material or a mixture of all of them, which ever they think will work the best. To give you an idea of the sort of designs they should be aiming for, the lightest design ever to win in the 15 or so years I have been doing this used just 2g of packaging material. They strategically stuck about a dozen packaging shapes end-on around their egg with tiny bits of tape folded to make it double-sided. More realistically, winning designs usually weigh in at between about 8g and 15g of material, this is equivalent to a couple of layers of bubble wrap or an egg-shaped shell of expanded polystyrene carved to fit closely to the egg. I usually say that the design must fit easily on to the pan on my scales, so there is no need to produce anything the size of a football, aim for something more like the size of a tennis ball. Get them to think back to cycle helmets - you wouldn't wear it if it was huge!
- Get the teams to think about the properties of eggs, whether they are stronger in one direction whether they can use this to their advantage in their design.
- While they are doing the designs walk around and discuss them with the groups and at the same time, give out lengths of tape (about the length of the short side of a school table). With relatively small groups this works better than having the tape on the workstations already as it can get damaged.

Prepared by
Dr Diane Aston, IOM3

Build phase (10 minutes)

- Before the groups start building their design,s I usually give them a few important instructions (most of these are commons sense really but worth noting):
  - Be careful with the scissors while cutting the materials. If they need help with a tricky bit, ask for it.
  - Be very careful with their egg as it is the only one they will get. No breaking other group's eggs either! If you have spare eggs you can introduce a weight penalty for teams that have broken one so that they can still take part; a 5g penalty is about right.
  - Be careful with the tape, if they fold it up and get it stuck to itself they won't get anymore.
  - Use their materials sparingly, as these are the only ones they'll get!
  - Keep their work area tidy. I usually get the teams to tidy up and put everything away before testing.
  - There is no rush to finish. Everyone will get the same amount of time and if they finish in the first couple of minutes they will just have to sit around and wait for everyone else.
- Build time is often a bit frantic and it is useful to have an extra pair of hands or two to keep an eye on the group.
- Each group will need an egg. You can either give these out or get one person from each team to collect and egg while the other gets the scissors.
- On the pupil worksheet there is space for them to record their egg number and how much it weighs. On your Master Sheet there is space for you to record the mass of the eggs and the team names, I usually walk round the group while they are building to write the names down and make sure they have recorded their egg number and its mass. An extra pair of hands is very handy at this point!
- At the end of the build time I get them to come and reweigh their eggs wearing their crash suits. There is space on the pupil handout and master sheet to record this and to work out and record how much material has actually been used. Once this is done and everything is tidied up its time for the fun bit...

Test phase (20 minutes)

- The duration of the test phase depends very much on the number of groups, their age and ability to get on with it. Testing will generally take 1 to 2 minutes per team.
- While the groups are finishing tidying up I work out the order that the designs will be tested in. Rather than just go down the list, to make things a bit more interesting I test the designs heaviest to lightest, as it's the lightest design that wins! I also tape a bin bag or plastic sheet on to the floor to act as a drop zone (to contain any eggy mess!). Your extra pair of hands will be of greatest use at this stage as your Official Eggsaminer whose decision is final!
- Call out the teams in turn and ask each group to come to the front and tell the others about their design. Ask them to present you with their design the way round that they would like you to hold it and then drop it!
- Your Eggsaminer should pick up the dropped designs and carefully get in to them to see if the eggs are OK. As a broad rule of thumb, if the design bounces the egg is usually OK, if you see yellow get a paper towel!
- This bit is really good fun! We often have a countdown for each drop or a drum roll but then try to get the pupils to be quiet during the actual drop to see if they can hear the splat!! Try to make this bit as exciting as possible, maybe even a bit theatrical!
- Deciding the best design prize is easy, it is the lightest one that doesn't break.
- It is good to get the pupils to decide the best team name by putting their hand up for the one they like best. I tend to say they can only vote once and they can't vote for themselves.

Evaluation phase (5 minutes)

- Once all the designs have been tested encourage the teams to discuss and record whether their design worked and how it could be improved. If it failed could they have used different materials and if it survived, how could they make it lighter?
- Encourage them to compare their design to a real helmet and scale the sizes up. For example, a 65g egg wearing a 10g suit would scale up to a 65kg person wearing a 10kg suit which is very heavy! Real cycle helmets tend to weigh well under 500g.
- While the teams are completing their evaluations you will have a chance to fill names in on the certificates for the winners.
- Finish off by awarding the prizes and encouraging the group to go away thinking more about the materials around them and taking them less for granted.

Extension ideas

- You could run this project in a number of other different ways depending on the age group and ability of the pupils you are working with and the amount of time you have got to spare. These are just a few suggestions.
- FORCES – Get the pupils to think about the forces acting on the egg as it falls and see if they can calculate the speed that the egg hits the ground at.
- HEIGHT OF DROP – Test the designs from increasing heights. You could use a stairwell to do this and count the number of stairs. Keep going up a step until the design fails. You might need to give the groups extra materials to do this.
- USE OF DIFFERENT MATERIALS – Introduce other materials to the challenge.
- QUANTITY OF MATERIALS – Do not make up individual material packs. Instead give the teams a monetary allowance and get them to buy materials. Make up prices for each of the material types. For example, allow each team £5 and then charge 25p for each packing chip, £2.50 for each 10x10cm sheet of bubble wrap, £1.00 for each 8x8x2cm sponge and 20p for every 10cm of tape. See who comes up with the best (lightest) design for the cheapest price.

Prepared by
Dr Diane Aston, IOM3